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ABSTRACT

A study undertaken in Ireland investigated the effectiveness of a second language teaching strategy that focused on grammatical problem-solving. In this approach, the problems are located within the target language system, and the problem-solving involves induction of grammatical rules and use of those rules. Learners are confronted with instances of a specific grammatical problem, from which they induce a generalization about form and function. They are provided with tools for solving the problem, such as examples, hints, and feedback. Learners are then given opportunities to use the rules to confirm them, observe how the new rules interact with others, and explore relationships between linguistic structures and their communicative values. Subjects were approximately 100 secondary school graduates, all foreign nationals, attending pre-university courses leading to the Irish school leaving certificate examination. Participants were placed according to ability level and randomly divided into experimental (problem-solving) and control (conventional grammar instruction) groups. Instruction covered six topics of grammar: articles; quantifiers; past simple vs. present perfect tense; logical connectives for addition, contrast, concession, and cause/effect; relative clauses; and passive voice. Experimental subjects found the approach effective and relevant and achieved greater gains in both competence and performance than did control subjects. (MSE)

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The case for problem solving in second language learning

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The case for problem solving in second language learning

by

James Mannes Bourke

1 Problem solving and the development of linguistic competence

1.1 Overview

The use of problem solving as a communicative interactive technique in EFL/ESL has been advocated by several writers (e.g. Klippel 1984, pp.102-114), and this type of task-based problem solving has by now become well-established in the L2 classroom.

There is, however, another kind of linguistic problem solving which is much less widely known, viz. grammatical problem solving in the narrow sense of syntax. This new brand of linguistic problem solving incorporates features which from a "communicative" viewpoint might be regarded as ineffective in promoting L2 development. I am referring to features such as

- consciousness raising in the form of linguistic analysis;
- a focus on cognitive strategies, especially hypothesis testing, inferencing, risk taking;
- an emphasis on comprehension rather than production;
- a major role for formal instruction in the form of specific learning procedures;
- a syllabus keyed to the language problems of the learner.

In this type of linguistic problem solving the "problems" are located within the target language system, and it is my contention that this type of systemic problem solving builds linguistic competence and should play a key role in L2 pedagogy.

The problem-solving approach I am speaking of is based on the

hypothesis first proposed by Winitz and Reeds (1975, p.3) that language learning is essentially a problem-solving activity—a view implicit in Chomskyan theory and supported by later psycholinguistic research, which takes the view that "the central learning process for acquiring a language is hypothesis testing" (Seliger 1988).

1.2 Motivation for the present study

The purpose of the research reported in this paper was to determine whether there were empirical grounds for taking the Winitz-Reeds position seriously in the L2 classroom. My interest in linguistic problem solving grew out of my experience as an EFL teacher. I found that adult learners especially were deeply interested in grammar and were very keen to bridge a perceived "grammar gap" (Bourke 1989) in their learning of English.

Unfortunately, the conventional approach to grammar teaching/learning does not seem to have worked very well. The model one finds even in the most recent textbooks rests on an ordered progression from examples through explanation to exercises. As Pearce (1990) and others have pointed out, the conventional model is seriously flawed. It is teacher-centred and there is minimal learner participation. It is largely predictable, boring and unchallenging for the learner. It very often misses the crucial problem element facing the learner. For instance, it may deal with each of the English tenses individually yet fail to account for tense switching in a text. It thus presents a very fragmented view of the language system. Moreover, it rests on the assumption that grammar is "received" in prefabricated chunks (or "accumulated units", as Rutherford [1987] calls them), and it makes no reference to one's internalized grammar, which is not acquired in a full-blown form but evolves slowly over time. In a word, conventional grammar is what Chomsky calls "E-language" (externalized language), while the learner's internalized grammar is "I-language". Whereas learners are concerned with "I-language" (i.e. knowledge in the mind in the form of "rules" or "principles"), teachers and textbooks have tended to cling to "E-language" models in the form of structural or descriptive statements. But it is clearly very difficult, if not actually impossible, to acquire "I-language" using "E-language" instruments. It seems quite pointless, therefore, to put learners through a series of grammatical hoops as many textbooks do. A traditional taxonomic approach tells us nothing about the mental processes at work and it does not have much relevance within a

"discovery" approach. What is meant by a problem-solving approach to grammar is that learners must play an active part in discovering significant facts for themselves. Rules, therefore, are not prescriptive statements in the traditional sense, or long lists of structures, but generalizations found to operate in a number of specific instances. A problem-solving approach to grammar is a model of learning.

A problem-solving approach to grammar teaching/learning has none of the limitations of the traditional formula. It is learner-centred, i.e. learners themselves work inductively towards a solution. They are actively involved at all stages. They are given tools for the job, e.g. a worksheet, and they start working on the problem immediately, either individually or in groups. Learners have to think and make decisions. Their attention is focussed for teacher input. Language learning is thus viewed as a cognitive event which does not violate the natural process of language acquisition.

A problem-solving approach rejects the view that all language learning takes place "underground" as a product of the hidden processes of the mind. While it cannot be denied that children acquire their mother tongue without invoking conscious cognitive strategies, it cannot be assumed that the same procedure is either possible or desirable in the case of L2 learners, and especially adult L2 learners. Many adults feel the need for well-defined "discovery procedures" which they can use to build a mental model or map of the target language system. Since their learning style is largely analytic and formal, it would be counter-intuitive to reject conscious learning. Besides, it is not always possible to replicate in the L2 classroom the conditions necessary for natural acquisition. And since most language learning takes place in acquisition-poor environments, viz. classrooms, it would be unwise to rely entirely on "nativist" procedures.

Problem solving in this context refers to two complementary learning processes, viz. rule getting and rule using. Rule getting refers to the induction of grammatical rules by means of guided discovery. Learners are not given the rule or allowed to look it up in a reference grammar. Instead, they are confronted with instances of the grammatical problem, which they analyse and from which they induce a generalization about its form and function. Learners are thus actively engaged in the learning task, which in turn increases motivation. They are given various tools for the job, such as examples, hints, feedback, etc. Rule using refers to the use of rules to express grammatical notions. Learners are given the opportunity to use the

rules they are working with in order (a) to confirm that the rules actually work, (b) to observe how a new rule interacts with other rules, and (c) to explore the mappings between linguistic structures (e.g. modal verbs) and their communicative values (e.g. obligation, ability, etc.).

1.3 Rule-getting procedures

The problem-solving task can be presented by means of "perceptual frames", i.e. short dialogues, narratives, expository texts, etc., which serve a twofold purpose: (a) providing a meaningful context to demonstrate instances of the problem, and (b) as a means of cueing the generalization that the language learner must induce.

The input frames are seeded with pertinent data and are carefully sequenced to address different aspects of the problem under study. For example, in presenting the article system in English, one might look at a series of binary contrasts:

(i) count versus mass;

(ii) *a* versus *an;*

(iii) *the* versus *a/an;*

(iv) zero article versus article.

Let us suppose the problem is correct discrimination between *a/an* and *the* in noun phrases. Using a problem-solving procedure, one does not state the rule; the learners have to infer it from a number of short texts or frames, each of which is seeded with several examples of the target structure. Learners would be asked to identify each usage of the articles in the frame and then infer a generalization governing article usage in English based on the clues provided. The learner would formulate a tentative rule and test it against further instances of article usage in subsequent frames, and it would thus be confirmed, rejected, or revised.

For example, the *a/an* problem might be presented to an elementary class as follows:

> **Problem:** Why is it *a leg* but *an arm*?
>
> Read the passage below and underline nouns with *a* or *an*. Enter these in the correct column:
>
> Tabby is an awful cat. He sleeps on a mat and never catches a mouse. He eats five times a day. He often sits in an armchair for an hour or more without making a sound.

Some people say he's a horrid cat, but I think he's an old rascal.

a *an*

.....
.....
.....
.....

The problem-solving procedure is a simple recursion comprising three moves:

(i) Read the text frame.

(ii) Form a hypothesis.

(iii) Test, and if necessary revise, your hypothesis.

The resulting "rule" is unlikely to be elegant in a linguistic sense, but it stands a good chance of being retained over time for the simple reason that it has been self-discovered.

I have, of course, used a very basic example. Could problem solving work equally well with more complex features, such as tenses, modal verbs, relative clauses, etc.? Based on my own classroom experience, I would say definitely yes. Any piece of language can be explored linguistically, and even though inductive learning is a slow process, it takes learners "inside" the problem and allows them to work towards their own understanding.

The type of rule-getting activities one uses will be determined largely by the nature of the problem. For instance, in teaching constrastive connectives to Upper Intermediate students I have used the story "The Clever Queen" (McArthur 1984, pp.55-58), which contains eight contrastive markers. The method I use is as follows. Students first read the text and identify all the contrastive devices in it. They are then guided towards finer discriminations. They may observe the two main kinds of contrast, viz. adversative and concessive, and note their associated semantics. They might also discover the three sets of grammatical devices which English uses for signalling each type, viz. conjunctions (e.g. *but*), sentence connectors (e.g. *however*), and subordinators (e.g. *whereas*). A good deal of observation, speculation and discussion will centre on the special attributes of each subset, determining, for instance, the form and position of the connective, whether movement is possible, and if so,

what impact this has on the rest of the sentence. It may be possible to add a usage gloss to each connective, indicating how it is marked for formality and emphasis,

e.g. X *but* Y (general/formal)
X *however* Y (more formal/emphatic), etc.

At a more advanced level one might look at the "ripple" effect of certain markers on the surrounding syntax, e.g. the various allowable configurations that collocate with *despite*:

despite [*the fact that he is old*
being old
his old age

Thus in one or two lessons the learners themselves can begin to come to grips with the complex problem of textual contrast. At all times, however, it is important to avoid stimulus overload by presenting too many problems at too fast a rate in contexts which are too contrived and/or too complex.

Linguistic problem solving may operate at word level, phrase level, sentence level, or text level. For example, in dealing with the problem of verbal complementation in English, one does not begin with the teacher saying: "Today we are going to look at gerunds and infinitives. Instead, the lesson might begin with students looking at a text, or a number of texts, containing several instances of gerunds and infinitives. From this source they would be able to draw up a concordance of usage which might yield a broad classification of verbal complements as follows:

C1:	*like to cook/cooking*	
C2:	*stop to smoke/smoking*	(meaning change)
C3:	*enjoy walking*	(gerund only)
C4:	*want to study*	(infinitive only)

Consciousness-raising exercises can range from observation of syntactic patterning and processes, to the making of judgements and discriminations, to the articulation of rules.

In this type of work we can employ for teaching purposes procedures that are normally only used in language testing. One way to teach students to process words in context, for instance, is through text-restoration techniques such as cloze procedure. Cloze calls for a high degree of lexical and grammatical sensitivity as well as the ability to recall and restore missing pieces. As such, it poses a direct

challenge to learners' linguistic knowledge. They have to solve the problem of providing an expression that is both systemically acceptable and at the same time schematically appropriate. While cloze is essentially an indicator of global competence, a "selective" cloze can be used to focus attention on specific language items. In this case, instead of random deletion, either function words (i.e. pronouns, articles, determiners, etc.) or inflectional morphemes are deleted (Madsden 1983, p.51). Cloze is too good a device to be used only for testing pruposes. It is also a useful teaching technique. It is easy to prepare. It can be freely adapted to highlight syntactic, lexical or discoursal clues. In fact, cloze may in the end turn out to be more suitable for teaching than for testing.

Another exercise type that might be used in developing linguistic awareness is error detection and correction. The ability to detect and correct errors stems from one's pervasive syntactic awareness, and is therefore a property of one's underlying linguistic competence. I believe that regular error correction should be part of the L2 learning experience. For example, in my lesson on articles, I always include an exercise where the learner is asked to identify errors and make corrections, e.g.:

**When I was in the Paris, I saw Mona Lisa*
**Bonn is a capital of the Germany*

Those of us who teach writing can use our learners' errors, put them up on the blackboard, and focus attention on them. I have found this kind of group therapy to be not only highly beneficial but also surprisingly popular as a classrom activity.

1.4 Rule-using procedures

The second aspect of linguistic problem solving that I wish to discuss is rule using, i.e. the growing use of grammatical rules to achieve expression. This is something close in meaning to Rutherford's (1987) notion of "grammaticization".

L2 learners cannot be exposed to the complete set of possible constructions in the new language. Instead, they have to isolate some general grammatical properties that they can project on to novel situations. This process of projection is crucial for learning. The extension of the newly formulated rule to other situations not only provides confirmation and clarification of the grammatical point under study, but also serves to refine the rule by introducing formal

or pragmatic constraints on its use.

It is clear that the pedagogical instruments needed for rule using cannot be those employed in rule getting. Whereas rule-getting activities are designed to raise grammatical consciousness by highlighting salient features, demonstrating syntactic processes, and showing how language works, rule using obliges the learner not only to "notice" but also to "perform an operation of some kind. In other words, it is C-R [consciousness-raising] activity that is task-oriented, where the learner is actively engaged in solving problems" (Rutherford 1987, p.153).

Unfortunately, over the years, grammar production exercises have tended to focus on the formal aspects of isolated sentences. Very often pattern drills, substitution tables and slot-filler exercises were used, which were notable for their yawn-provoking banality, meaninglessness, and lack of contextualization. In recent years, however, a number of stimulating and challenging types of grammar texts have appeared which have abandoned the examples → explanation → exercise routine, in favour of tasks or problems which enable learners to work inductively towards the solution. This new type of pedagogical grammar departs significantly from the conventional model in the manner in which it challenges learners to discover linguistic facts for themselves. Learners perform specific tasks which raise their grammatical consciousness and enable them to develop their "I-language". Amongst the exercise types that I have employed for rule using are the following:

(i) Propositional clusters

In this activity the learner is presented with what Rutherford (1987, p.59) refers to as a "propositional cluster", i.e. a semantic nucleus consisting of a verb plus associated noun phrases. The task is to grammaticize the cluster into a sentence. For example, the cluster *dog—tail—long* can be realized as "The dog has a long tail" or "The dog's tail is long". In performing this task learners have to work out for themselves the surface implications of particular syntactic options. It is a task that normally takes them beyond the domain of sentence grammar to that of discourse. Consequently, it is more valuable if the discourse setting is indicated, as in the following example: *Round the corner came a man and a dog. ride—man—black horse.* The most natural realization of this cluster would be "The man was riding a black horse": *man* rather than *horse* is chosen as subject in accordance with

the given/new principle; in other words, *man* has already been raised to consciousness in the preceding sentence.

The propositional cluster has several pedagogical advantages. It is easy to construct, yet it challenges the learner in whatever specific language area you choose to focus on. It serves to highlight the interdependence of syntax, semantics, and discourse. Finally, the level of complexity can be varied in several ways; for instance, by the number of functions assigned to the verb, by the use of premodification, by the introduction of modality, and by the elaboration of embedded material (Rutherford 1987, p.167), e.g. *want—child—[sing—child—song]*, "The child wanted to sing a song".

(ii) Text reconstruction

The concept of embedding as manifested by complementation and relativization is a major aspect of grammaticization that can be approached from a problem-solving perspective by means of text re-creation. The following example illustrates complementation in a text re-creation task (the verb complement appears as a full sentence in brackets):

> British students have not yet come to terms with (We are all Europeans now). European students have succeeded (They learn two or more foreign languages) but it seems (Most British students wish to remain monolingual). While the French and the Germans find (They learn English) important, students here find (They acquire a foreign language) unpalatable.

(iii) Paraphrase

Paraphrase is part and parcel of the process of communicating. If we observe two people conversing, we note a process of continual linguistic modification as both speakers seek to ensure comprehension by reformulating their utterances.

Paraphrase is also a very powerful pedagogical tool for syntactic and lexical exploitation. Moreover, it can be employed at different levels of L2 proficiency. For example, having analysed the form and function of the present perfect tense in English, one could devise various stimulus sentences using the present perfect, e.g. *Tom no longer lives in Paris* ⟶ *He has left Paris.* Paraphrasing is especially beneficial in composition work where the aim is to develop flexibility of expression. It can be open or closed, i.e. the source sentence can be

reformulated in any acceptable way or it may be clued to elicit a specific structure, e.g. *The boy sang a song* ⟶ *A song* .... At a more advanced level, it has enormous potential as a tool for converting clauses into phrases and vice versa, e.g. in clause-phrase reductions of the type *When she heard the news, she sighed* ⟶ *Having heard the news, she sighed.*

(iv) Dictogloss

Another very promising technique that can be used to enable L2 learners to activate their knowledge of the target language system is dictogloss. The main features of dictogloss can be summarized thus:

(i) Wajnryb (1989, p.16) recommends that the text used should hang together as a semantic whole. It should display the features of a well-written paragraph in terms of topic development and textual coherence. It should normally be quite short, anything between three and seven sentences long. It should not be lexically overloaded and it should have a structural focus.

(ii) The students are placed in small groups and the text is read at normal speed, sentence by sentence, and not word by word or phrase by phrase, as in traditional dictation. The pause between sentences may be slightly longer than usual. During the dictation, students note down key words and phrases, i.e. content words rather than structure words.

(iii) Next comes the re-creaton stage. The students re-assemble their fragments into a coherent whole. It is a co-operative venture. The members of each group pool their notes and their linguistic resources to reconstruct the text. However, the aim is not to generate an exact replica of the original. As Wajnryb notes: "It may help to think of this procedure as the opposite of cloze: in the cloze, we have a text with holes or gaps; in dictogloss we have fragments in need of a text."

(iv) Finally, we come to the whole-class analysis and correction stage, in which the different versions are read, discussed and evaluated. The learners themselves are allowed to sort out errors and justify their positions. The focus of this activity will be the target structure(s) and possibly other syntactic or lexical points related to it.

The idea in all this is that learners learn from the experience of

producing language.

Let me at this point recapitulate my thesis. I began by making a very strong claim for problem solving, viz. that it builds linguistic competence and thus facilitates our capacity to "grammaticize". It does this, I propose, by the twin processes of rule getting and rule using. I am in fact saying that problem solving is the procedure by which we discover and internalize the rule system of the target language. This is indeed a very big claim, but in the second part of the paper I shall set out empirical support for my position.

2 Experimental work and research findings

2.1 Problem solving in operation

In the proposed problem-solving model, grammar learning is thought of in terms of two complementary processes, viz. rule getting and rule using. I have already defined heuristic problem solving as

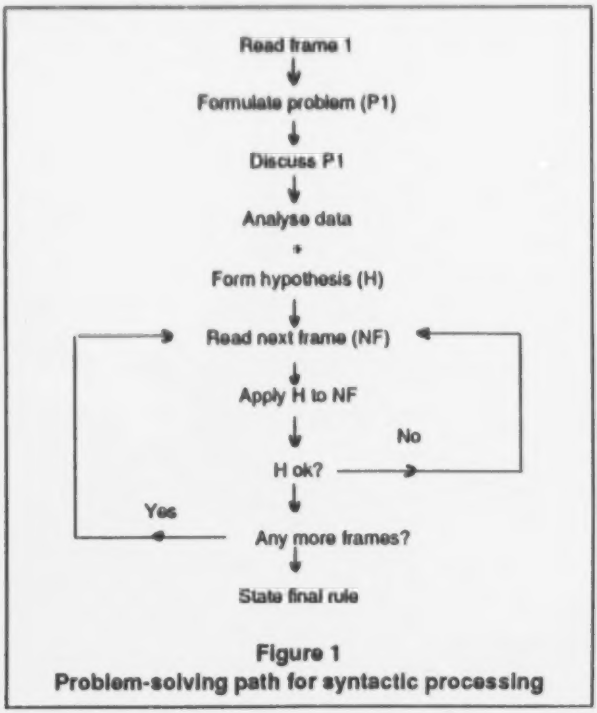

Figure 1
Problem-solving path for syntactic processing

a strategy which enables the learner to induce various kinds of generalizations from a given set of inputs. "Problem solving is always a matter of search" (Newell 1977, p.47). Figure 1 illustrates how the search proceeds when the goal is a linguistic rule. The problem-solving procedure commences with problem finding and proceeds through data analysis, hypothesis forming, hypothesis testing and frequent rule revision, to the final rule formulation. The procedure itself is a simple recursion comprising three moves:

(i) read the next frame (NF);

(ii) form a hypothesis (H);

(iii) if necessary, revise hypothesis.

The learner cannot stop at this point, however, because grammar is not "an unapplied system in the head". In terms of our model, we have to move on from rule getting to rule using. All new rules have to be integrated into the learner's "network of knowledge 'how'—that is, his ability to grammaticize" (Rutherford 1987, p.51). A number of procedures for this latter task were outlined in the first part of this paper.

2.2 Experimental design

The present study looks at the effect, if any, of problem solving (the independent variable) on adult L2 linguistic competence (the dependent variable); see Figure 2.

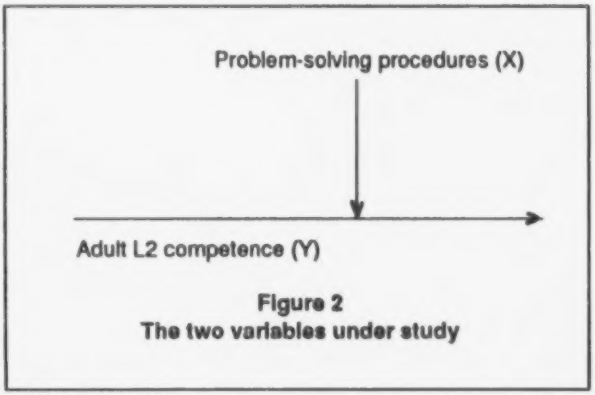

Figure 2
The two variables under study

Status studies of this type are quite common and there are a number of research designs and statistical procedures one can use to establish and quantify the effect of variable X on variable Y. The traditional approach is to collect quantitative data under controlled circumstances and then subject it to statistical analysis. In the present experimental context, the data took the form of text scores obtained before and after the administration of a short programme of instruction.

2.3 Objective

The research aimed to demonstrate that in the case of adult L2 learners, problem-solving procedures (as described in the first part of this paper) correlate positively with gain in linguistic competence.

2.4 A small-scale experiment

Language learning is a complex human activity which cannot be usefully investigated in laboratory conditions. L2 teachers operate not in laboratories but in classrooms, and not with carefully selected groups but with fairly large classes of mixed linguistic and cognitive ability. Not surprisingly, recent trends in L2 learning research favour small-scale "in class" experiments. In this way it is possible to preserve the integrity of the classroom situation, while the variables under scrutiny can be quantified by means of rigorous testing instruments.

Ideally, what one wants is an experiment which will balance internal and external validity. In the context of research, validity is defined as "the extent to which the outcome is a function of the factor you have selected rather than other factors which you haven't controlled" (Hatch and Farhady 1982, p.7). Having a control group is the normal means of assuring internal validity. One wants to be sure that the outcome is specifically related to the treatment variable and not to any other extraneous factor(s). Both control and experimental groups are selected on the same basis, the only difference between them being that the control group does not receive the experimental treatment, which in this case is problem-solving instruction.

External validity in research design refers to "the extent that the outcome of any research study would apply to other similar situations in the real world" (Hatch and Farhady 1982, p.8). The normal way of assuring external validity is random sampling, i.e. subjects are

randomly selected and assigned to either experimental or control groups. Normally, in language schools, it is not possible to provide a researcher with randomly assigned classes. However, in the present case the experimenter was given the freedom to set up several randomly assigned groups, any one of which could have been selected as either experimental or control group.

2.5 Subjects and setting

The experimental lessons were given at the Institute of Education, Dublin, where in 1989-90 there were some 100 overseas students attending pre-university courses leading to the Irish Leaving Certificate Examination. These students took five subjects, three at Higher Level and two at Lower Level, including English language and literature.

The students were for the most part teenagers or young adults who had graduated from their respective secondary school systems. The great majority came from the Middle East and South East Asia. Their knowledge of spoken English was generally good, but their knowledge of grammar and written discourse was often extremely weak. They were of approximately Upper Intermediate proficiency.

2.6 Sampling

On arrival at the Institute all subjects took a placement test. On the basis of this test "high achievers" (subjects scoring 80% or more) were assigned to a special fast-pace class, while "low achievers (subjects scoring less than 40%) were assigned to a special remedial programme. The remaining 75 subjects were assigned to four groups by means of stratified random sampling. In other words, they were ranked by score into four groups and these groups were then redistributed by selecting randomly across the four groups in turn. Thus each of the four resulting groups was equally representative of the normal population.

Experimental and control groups were also randomly selected. Initial difference between the experimental and control groups was controlled by administering the same pre-test to both. Both groups then followed the same grammatical syllabus for 10 weeks, covering the same ground in the same sequence and receiving the same amount of instruction, viz. 20 hours. The experimental group, taught by the researcher, used problem-solving instructional procedures, while the control group, taught by another teacher, followed a

conventional method, consisting of the following stages:

(i) explaining the new teaching point by examples on the blackboard;

(ii) oral drills to manipulate the new item;

(iii) written practice from the students' textbook or a hand-out.

On completion of the instructional programme both groups were given the same post-test.

2.7 The teaching programme

The teaching programme consisted of six grammatical topics selected from the language syllabus. The experimental lessons were selected so as to be a representative sample of the course. They included discrete points of structure such as determiners, verbal systems, complex sentences, and logical connectives within and between sentences. The grammar was that found in formal written texts. The teaching programme was as follows:

Lesson 1	Articles: *a, an, the,* zero article
Lesson 2	Quantifiers: *some, any, much, many, few, a few,* etc.
Lesson 3	Past simple versus present perfect tense
Lesson 4	Logical connectives for addition, contrast, concession, and cause/effect
Lesson 5	Relative clauses, defining and non-defining
Lesson 6	Passive voice

2.8 Testing

A secondary but important part of the research was an attempt to characterize "competence" and "performance" tests empirically. The process of test development—which cannot be described in detail here—was a lengthy one involving several pilot runs and a good deal of statistical analysis. However, the attempt to isolate competence and performance tests was not supported statistically.

The final version of the "competence" test battery consisted of three sub-tests, viz.:

(i) multiple choice;

(ii) cloze procedure;

(iii) error detection/correction tasks.

The final version of the "performance" test battery consisted of:

(i) propositional clusters (see pp.8f. above);

(ii) sentence paraphrase;

(iii) a picture description task.

2.9 Materials production and use

One of the major tasks facing the research was the detailed planning of the experimental lessons and the writing of appropriate problem-solving materials. It should be stressed that the teaching materials were produced "from cold" in a rather short time and represent the viewpoint of one individual. Authentic materials were not used in the textual presentations.

The lessons depended on "finely tuned" input. It would have been impossible to use only authentic materials while at the same time following a predetermined structural path. The lessons were text-based. Each student was given a hand-out containing eight to ten pages of material divided into three or four sections, each section dealing with a different aspect of the problem. Each lesson took the learner through a series of tasks, some of which were done individually while others were done in pairs or small groups. There were frequent discussion intervals and check-points to provide feedback. The aim was to provide as much whole-class participation as possible. This discussion was done in English and posed few comprehension problems for the group. There was very little discussion of abstract principles; most of the discussion arose naturally out of the tasks, for instance, learners made observations, noted recurring features of a particular structure, formed hypotheses, and so on. The range of activities that the learners were engaged in and the type and amount of guidance they were given depended on the nature of the problem. It was up to the teacher to keep the lesson moving and to impose time limits when necessary.

The lesson materials displayed none of the attractive features of modern textbooks, such as colour photographs, illustrations, etc. In fact, most of the presentation and practice material was as dry as dust, and the fact that the learners still found the course stimulating can only be ascribed to the appeal of problem-solving.

A full account of the six experimental lessons and the testing instruments used can be found in Bourke (1990, chapters 8 and 9).

2.10 Affective evaluation

Before evaluating the cognitive effect of the instructional programme, it was felt necessary to conduct an affective evaluation of the teaching and the procedures by which it was delivered. This was done by administering a Likert-type questionnaire (see Appendix 1) to the experimental group. Unless an instructional process purporting to facilitate significant gains in learning also produces a favourable affective outcome, it cannot be regarded as a total success.

There are always perils in introducing new teaching procedures. Learners, at least initially, tend to reject the unfamiliar. The teaching programme used in the experiment certainly did not have any great intrinsic appeal to learners. It consisted of what might be considered rather dull teaching material, viz. grammatical topics such as articles, quantifiers, tenses, etc. The materials and exercises handed out were singularly devoid of humour, thematic interest, or colourful packaging. There were few pictures or other visuals. Yet the reaction of the group to the experimental lessons was most favourable and manifests a very high positive attitude towards grammatical problem solving, as is revealed by an analysis of the results of the Likert attitudinal ratings. The Likert five-point scale measures attitude to or opinion of a subject. Respondents were required to indicate the degree of their agreement or disagreement with six statements by circling the appropriate point on the scale.

When the responses were converted to numerical values, the questionnaire yielded a mean attitude score of 26.077 out of a maximum of 30 points. This figure represents a favourable rating of 86.92%. In view of the fact that the questionnaire included negatively as well as positively slanted items, the outcome was much higher than had been anticipated and can be interpreted as a very positive endorsement of grammatical problem solving by those who matter most, the learners themselves.

In a subsequent informal discussion with the group, the experimenter elicited two factors that could possibly explain this extremely high rating. First, there was the perception by learners that problem solving worked for them. They liked it because it enabled them to work things out for themselves rather than have ready-made solutions provided. Secondly, there was the perception of relevance. The problems were "their" problems, and this fact gave the learners a personal stake in the learning process.

2.11 Cognitive evaluation

The hypothesis to be evaluated in the present study was that adult EFL learners would develop linguistic competence more efficiently through exposure to problem-solving procedures than through exposure to conventional learning/teaching procedures. The criterion measures used to evaluate subjects' gain in learning were the "competence" and "performance" test batteries specifically designed for this purpose. The teaching programme on which the evaluation was based has been outlined above. The evaluation sought to establish whether there was a marked difference between the achievement scores of the experimental and control groups. A significantly higher mean gain for the experimental group would indicate strong support for the problem-solving approach.

Tables 1 and 2 show the differences in the means of the pre-test and post-test results. Following Fathman (cit. Long 1983, p.365), percentage gain scores for the two groups were computed by dividing the actual pre-test/post-test gain by the total possible gain. (Actual gain = post-test score minus pre-test score; total possible gain = maximum possible test score minus pre-test score.) In the "competence" test the experimental group achieved a mean gain of almost

Table 1 "Competence" test score means for control and experimental groups

Group	Pre-test	Post-test	Gain
Control	24.31	30.00	15.96%
Experimental	27.15	46.31	58.29%

Table 2 "Performance" test score means for control and experimental groups

Group	Pre-test	Post-test	Gain
Control	14.31	16.38	4.55%
Experimental	17.85	35.23	41.24%

60% from pre-test to post-test, whereas the control group achieved a mean gain of only 16%. In the "performance" test the experimental group achieved a mean gain of over 40% from pre-test to post-test, whereas the control group achieved a mean gain of only 4.5%.

In order to determine whether the differences observed in the pre-test and post-test data were statistically significant, a paired t-test was run. Table 3 shows the t-values for the four sets of data given in Appendix 2. Since $t(12) = 4.318$, all four sets of data are significant at the .0005 level. The significantly greater gain scores achieved by the experimental group on both "competence" and "performance" tests indicate a clear advantage for learners employing problem solving.

Table 3	Paired t-test values			
	Set 1	Set 2	Set 3	Set 4
t-value	12.90	10.20	4.92	4.55
df.	12	12	12	12

2.12 Discussion

The main finding of the present study is that there is a positive relationship between problem-solving instructional procedures and gain in linguistic competence and performance. The gain scores achieved by the problem-solving group over the non-problem-solving group were so striking that the outcome must be interpreted as a genuine effect for problem solving. It can safely be inferred, therefore, that problem-solving instructional procedures may be used to the advantage of learners in developing both linguistic competence and performance.

However, one must be careful not to overgeneralize from a single small-scale experiment finding in favour of problem solving. The experimental data indicate that problem solving is of considerable benefit to well-motivated adult EFL learners, both in formulating target-language rules and in using them. It is tempting to assume that the same finding would apply to other groups of learners in different learning contexts. It might also be reasonably expected that the problem-solving process could be usefully exploited in other areas of language learning, such as reading, writing, lexis, discourse analysis,

ESP, etc. However, in all these cases the effectiveness or otherwise of problem solving would have to be established in a number of trials over an extended period of time.

Finally, one should not overlook the practical implications of problem solving for class management. For example, it might not be the most economical learning system in a programme where time is of the essence. Inductive learning is a slow process, and even though it can be defended on theoretical grounds in that the learning that it promotes is more significant, more personalized, more enjoyable, and better retained over time, it might not be the ideal way to prepare a class for the Cambridge First Certificate examination!

Moreover, it is likely that some learners will be better, and therefore faster at problem solving, than others, and this could create tensions for the learners at either extreme of the ability range. It could also create problems for the teacher in deciding how long to let an activity run, and how much guidance to offer slower learners.

The experimental groups were quite fluent in English and had few problems in following instructions in English, formulating rules in English, testing them, etc. They had no difficulty in following discussion at quite a high level of abstraction, and were remarkably imaginative in inventing their own meta-language. Had the learners been at a very low level of proficiency, then classroom communication would have been a problem, unless the teacher had happened to know the learners' L1. It would therefore appear that a good reading knowledge of English is a prerequisite for problem solving to work effectively.

Furthermore, problem solving is very demanding on the teacher in terms of lesson planning and materials preparation. Problem solving is only as good as the materials and activities by which it is implemented. Unless teachers have the time, resources and inclination to seek out motivating input materials and adapt them according to the demands of the problem situation, and unless they can invent suitable follow-up activities, it is doubtful whether learners would succeed in working out their underlying grammar.

2.13 Conclusion

In spite of the practical difficulties outlined above, however, there can be little doubt that problem-solving strategies enable learners to internalize linguistic representations and thereby build linguistic competence. Accordingly, it would seem reasonable to suggest that

linguistic problem-solving should play a key role in L2 learning where the optimal conditions prevail.

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Appendix 1

Likert scale for the measurement of attitude towards problem solving

Instructions

Do you agree or disagree with the following statements which refer to the grammar programme that you have just completed? We would like to know whether you found problem solving useful or not. Indicate the extent of your agreement or disagreement with the following statements by circling the letters corresponding to your opinion about each statement.

SA = strongly agree; A = agree; U = undecided;
D = disagree; SD = strongly disagree

1. Problem solving makes grammar learning more interesting

   SA A U D SD

2. Problem solving makes grammar more boring

   SA A U D SD

3. Problem solving helps me to understand grammar better

   SA A U D SD

4. Problem solving makes grammar learning more difficult

   SA A U D SD

5. Problem solving allows learners to discover new facts

   SA A U D SD

6. Learners have little to gain from problem-solving exercises

   SA A U D SD

Appendix 2
Pre- and post-test scores

EXPERIMENTAL GROUP

	Set 1: Comp. test			Set 2: Perf. test		
	Pre	Post	Diff	Pre	Post	Diff
Max:	60	60		60	60	
Subject E1	23	36	+13	11	27	+16
Subject E2	21	43	+22	9	26	+17
Subject E3	32	52	+20	25	44	+19
Subject E4	34	48	+14	22	37	+15
Subject E5	16	40	+24	12	27	+15
Subject E6	22	49	+27	19	41	+22
Subject E7	23	42	+19	10	25	+15
Subject E8	12	34	+22	10	31	+21
Subject E9	32	59	+27	17	50	+33
Subject E10	36	56	+20	24	43	+19
Subject E11	29	39	+10	14	21	+7
Subject E12	36	50	+14	22	38	+16
Subject E13	37	54	+17	37	48	+11
Mean =	27.15	46.31		17.85	35.23	

CONTROL GROUP

	Set 1: Comp. test			Set 2: Perf. test		
	Pre	Post	Diff	Pre	Post	Diff
Max:	60	60		60	60	
Subject C1	22	30	+8	20	20	0
Subject C2	23	29	+6	14	24	+10
Subject C3	17	18	+1	9	9	0
Subject C4	33	39	+6	31	22	-9
Subject C5	26	34	+8	20	19	-1
Subject C6	25	28	+3	10	20	+10
Subject C7	17	29	+12	18	30	+12
Subject C8	16	25	+9	8	13	+5
Subject C9	32	32	0	12	14	+2
Subject C10	24	27	+3	9	4	-5
Subject C11	25	29	+4	20	15	-5
Subject C12	19	32	+13	6	8	+2
Subject C13	37	38	+1	9	15	+6
Mean =	24.31	30.00		14.31	16.38	

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